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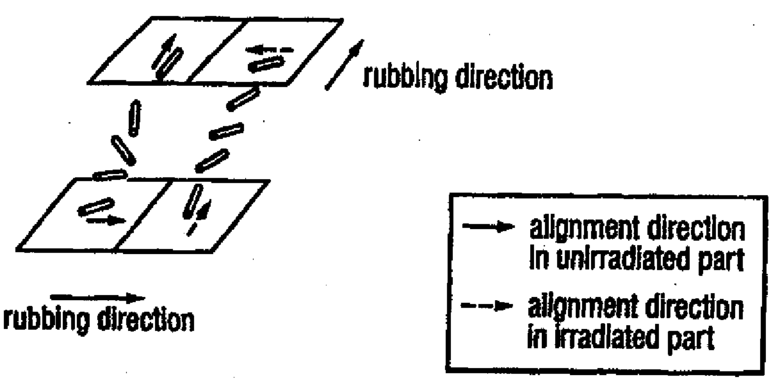
(54) Title: PROCESS FOR PRODUCING LIQUID CRYSTAL ALIGNMENT LAYER AND LIQUID CRYSTAL DISPLAY DEVICE WITH THE USE OF THE SAME



(57) Abstract

Process for producing liquid crystal alignment layer and liquid crystal display device using the same. More specifically, a process for conveniently producing an alignment layer, which allows for less viewing angle dependency and good display properties, and a liquid crystal display device using same. An alignment layer for a nematic liquid crystal display device characterized in that a part of the alignment layer has been irradiated with UV light or electron beam after the completion of the aligning process so that the alignment direction of the alignment layer within the irradiated region has been shifted by about 90° relative to the alignment direction established by the aligning process.

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Description

Process for producing liquid crystal alignment layer and liquid crystal display device with the use of the same

This invention relates to a process for producing a liquid crystal alignment layer and a liquid crystal display device with the use of the same. More particularly, it relates to a liquid crystal display device by which a wide viewing angle can be achieved.

A liquid crystal display device is an electro-optical device containing a liquid crystal material which undergoes changes in the optical characteristics when an electrical field is externally applied thereto. In recent years, liquid crystal display devices of the twisted nematic (TN) type have been widely applied to television sets, personal computers, etc., since they are thin and light weight and consume less electricity.

In a liquid crystal display device of the TN type, a liquid crystal alignment layer is formed on a substrate made of, for example, glass and the surface of the alignment layer is rubbed with a cloth, etc. so as to align liquid crystals, i.e., a so-called rubbing treatment. Namely, a liquid crystal alignment layer is obtained by forming a thin film of a heat-resisting polymer (for example, polyimide, polyamide) by spin coating, printing, dipping, etc. and drying or curing the polymer film followed by rubbing. A pair of these substrates are arranged so as the rubbing directions thereof being at 90° to each other and then a liquid crystal material is filled between them. Thus a liquid crystal display device of the TN type can be obtained. However, these liquid crystal display devices of the TN type suffer from a problem of viewing angle dependency caused by the anisotropic refractive index of liquid crystals. Namely, the color tone in intermediate colors varies depending on viewing direction.

To overcome this problem in the viewing angle dependency, there recently have been proposed a liquid crystal display device provided with two regions in one pixel, which differ from each other by 180° (in the upstanding direction of liquid crystal

molecule (K.H. Yang, IDRC, p. 68, 1991)), and a liquid crystal display device provided with two regions in one pixel, which differ from each other in pretilt angle (Y. Koike, et al., SID, p. 798, 1992). In these methods, however, two regions differing in alignment direction should be formed in each of the fine pixels, which requires photolithographic techniques, etc. Accordingly, such a method involves an increased number of steps and a complicated process. Thus, it is highly difficult thereby to economically produce a liquid crystal display device at a high yield. Also, an attempt has been made to irradiate polyvinyl cinnamate with polarized UV light thereby to align it in the direction of polarization without rubbing (Denki Joho Tsushin Gakkai Gijustu Hokoku (Technical Report in Society of Electric Information and Communication) Vol. 95, No. 155, p. 43, 1995). However, this method is not usable in practice, since the polyvinyl cinnamate material should be repeatedly irradiated with polarized UV light obliquely in order to form four regions differing in viewing direction. Moreover, it was believed that polyvinyl cinnamate would show no alignment after rubbing followed by the irradiation with non-polarized UV light.

Accordingly, an urgent need exists to develop a convenient method for improving the viewing angle dependency to give a liquid crystal display device with a less viewing angle dependency, thus solving these problems.

Accordingly, an object of the present invention is to solve the above-mentioned problems by providing a convenient process for producing an alignment layer, which allows for less viewing angle dependency and good display properties, and a liquid crystal display device with the use of the same.

The present inventors have now found out that the alignment direction of an alignment layer can be altered by forming an alignment layer by using specific polymers and irradiating the alignment layer with UV light or an electron beam after the aligning process, thus completing the present invention.

Accordingly, the present invention provides an alignment layer for a nematic liquid crystal display device characterized in that a part or the whole of the alignment layer has been irradiated with UV light or electron beam after the completion of the

aligning process so that the alignment direction of the alignment layer within the irradiated region has been shifted by about 90° to the alignment direction established by the aligning process. Irradiation of a part of the alignment layer of the present invention with UV light or electron beam makes it possible to form a region having the alignment direction established by the aligning process and another region having the alignment direction shifted by about 90° to the to alignment direction established by the aligning process in the alignment layer.

Fig. 1 shows the alignment of liquid crystal molecules in a liquid crystal display device provided with the alignment layer of the present invention.

Fig. 2 shows the alignment of liquid crystal molecules in a liquid crystal display device provided with the alignment layer of the present invention. In Fig. 2, the alignment regulation by the unirradiated part is stronger than that by the irradiated part and thus the alignment of the liquid crystal is regulated by the unirradiated part.

It is preferable that the alignment layer of the present invention contains a polymer compound [polymer (A)] which has such properties as to align the liquid crystal in the direction of the aligning process and another polymer compound [polymer (B)] which has such properties as to align the liquid crystal in the direction shifted by about 90° to the direction of the aligning process.

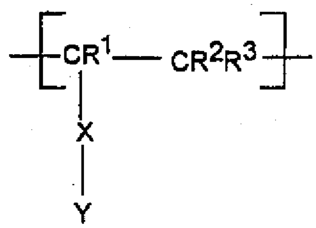
It is preferable that the polymer (B) to be used in the alignment layer of the present invention is a polymer compound having a bulky group, more particularly, a cyclic structure carrying at least 4 carbon atoms. It is also preferable that the polymer (B) has a polarizable group. The term "polarizable group" as used herein means an electron attractive group or an electron-donating group. Preferable examples of the polarizable group are as follows:

-C(=O)-, -C(N, -C(=S)-, -SO-, $-SO_2-$, -NH-, $-NR^4-$, $-NR^5R^6$, $-NH_2$, =N-, $-NO_2$, -N=O, -OH, -Cl, -F, -CHO, -COO-, -O- and -S-;

wherein R4, R5 and R6 represent each an alkyl group having 1 to 10 carbon atoms.

It is most preferable that the polymer (B) contains a repeating unit represented by

the following general formula (I):

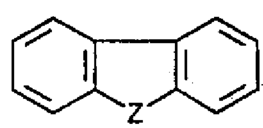
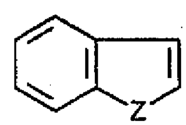


(I)

wherein R^1, R^2 and R^3 represent each a hydrogen atom, a halogen atom or an optionally halogenated alkyl group having 1 to 10 carbon atoms;

X represents a spacer unit which is a chain hydrocarbon group having 1 to 10 carbon atoms, a cyclic hydrocarbon group having 4 to 15 carbon atoms, -COO-, $-OCH_2-$, -OCO- or a direct bond; and

Y represents a cyclic hydrocarbon group having 4 to 15 carbon atoms, optionally containing at least one group selected from the following groups:
-C(=O)-, -C(N, -C(=S)-, -SO-, $-SO_2-$, -NH-, $-NR^4-$, $-NR^5R^6$, $-NH_2$, =N-, $-NO_2$, -N=O, -OH, -Cl, -F, -CHO, -COO-, -O- and -S-;
wherein R^4, R^5 and R^6 represent each an alkyl group having 1 to 10 carbon atoms, said Y may be substituted by an alkyl group having 1 to 10 carbon atoms or a phenyl group. It is preferable that Y is a cyclic hydrocarbon group selected from the following groups:

wherein Z represents a nitrogen, which is preferably substituted by H, an alkyl group having 1 to 10 carbon atoms or a phenyl group, sulfur or oxygen atom; and one to three =CH- groups on the ring may be replaced with =N-.

In the present invention, most preferable examples of X include -COO-, $-OCH_2-$, -OCO-, $-CH_2-$, $-C_2H_4-$ and non-polarizable cyclic hydrocarbons such as phenylene, naphthylene, cyclohexylene and cyclopentylene.

In the present invention, most preferable examples of Y include b-carboline, cinnoline, quinazoline, purine, isoquinoline, quinoline, quinoxaline, phthalazine, naphthyridine, isoindole, indole, pyridazine, oxolane, 2-furaldehyde, inden-1-one, fluoren-9-one, 2-pyridone, 2-quinolone, 9-carbonyl fluorene, thiophene, acridine, phenylpyridine, fluorophenylpyridine, fluorobenzene, fluoromethylbenzene, o-trifluoromethylaniline, pentafluorobenzene, o-methoxybenzaldehyde, cyanobenzene, methylcarbamoylbenzene, carbamoylimidazole, benzoic acid, chlorobenzene, nitrobenzene, nitronaphthalene, aminobenzene, aminonaphthalene, sulfobenzene, aminopyridine, carboxypyridine, hydroxybenzene, hydroxypyridine, fluoromethylpyridine, formylbenzene, aminoethylbenzene, hydroxymethylbenzene, trifluoroethylbenzene, cyanoethylbenzene, formylethylbenzene, methoxyaminobenzene, 4-amino-tetrafluoropyridine, difluoromethylbenzene, difluorobenzene, methoxybenzene, aminocyclohexane, aminocyclopentane, cyclohexanecarboxylic acid, hydroxycyclohexane, fluoromethylcyclohexane, cyanocyclohexane, formylcyclohexane, fluorostyrene, difluorostyrene, trifluorostyrene, tetrafluorostyrene, pentafluorostyrene, trifluoromethylstyrene and bis(trifluoromethylstyrene).

In the present invention, most preferable examples of the polarizable group include -C(=O)-, -CN, -NH-, $-NR^4-$, $-NR^5R^6$, $-NH_2$, =N-, -F and $-NO_2$ wherein R^4, R^5 and R^6 represent each an alkyl group having 1 to 10 carbon atoms.

As the polymer (A) to be employed in the alignment layer of the present invention, it is preferable to use a polyimide, polyamide, polyether, polyester or polyurethane, more preferably one having fluorine or siloxane group, and still more preferably a polyaramide siloxane compound.

The present invention further provides a process for producing an alignment layer for a nematic liquid crystal display device characterized in that the whole alignment layer or a part thereof is irradiated with UV light or electron beam after the completion of the aligning process so that the alignment direction of the alignment layer is shifted by about 90° to the alignment direction established by the aligning process.

The present invention furthermore provides a liquid crystal display device having a nematic liquid crystal material filled between a pair (upper and lower) of substrates each comprising a transparent electrode and an alignment layer formed thereon in such a manner that the alignment layers are arranged inside, characterized in that at least one of the substrates has the above-mentioned alignment layer of the present invention formed thereon.

According to the present invention, the surface of an alignment layer is irradiated with UV light or electron beam so that the alignment direction of the irradiated region is shifted by about 90°, more particularly from 85 to 95°, to the alignment direction established by the aligning process. The term "alignment direction of the alignment layer" as used herein means the direction along which the liquid crystal is to be aligned on the surface of the alignment layer. By appropriately combining the irradiated and unirradiated regions of the upper and lower substrates as shown in Fig.1, it is therefore possible to form two regions wherein the alignment directions of liquid crystal filled between the substrates are at about 90° to each other (i.e., differing in the viewing direction by about 90° in a single pixel, thus widening the viewing angle.

As the alignment layer material employed in the present invention which is irradiated with UV light or electron beam so that the alignment direction of the irradiated region is shifted by about 90° to the alignment direction established by the aligning process, use can be made of photosensitive polymers having unsaturated bonds in the molecular chain such as polyvinyl cinnamate. When irradiated with UV light after the aligning process, such a polymer undergoes dimerization or isomerization and thus its alignment direction is shifted by about 90°.

Alternatively, the alignment layer of the present invention can be obtained by mixing at least one polymer compound [polymer (A)], which has such properties as to align the liquid crystal in the direction of the aligning process when the alignment layer is irradiated with UV light or electron beam after the completion of the aligning

process, and at least one polymer compound [polymer (B)] which has such properties as to align the liquid crystal upon irradiation in the direction shifted by about 90° to the direction of the aligning process.

By mixing the polymers (A) and (B) at an appropriately mixing ratio, it is possible to obtain an alignment layer which has the alignment direction established by the aligning process after the completion of the aligning process, and has the alignment direction shifted by about 90° to the direction of the aligning process after the irradiation with UV light or electron beam. That is to say, the proper selection of the combination of the polymers (A) and (B) and the mixing ratio thereof makes it possible to give an alignment layer in which the alignment by the polymer (A) becomes dominant after the aligning process while the alignment by the polymer (B) becomes dominant after the irradiation with UV light or electron beam. After the completion of the aligning process, the alignment in the alignment layer of the present invention is regulated more strongly by the polymer (A) than by the polymer (B) and thus the liquid crystal is aligned in the direction established by the aligning process. On the other hand, when the alignment layer is irradiated with UV light or electron beam, the alignment regulation by the polymer (A) is weakened while that by the polymer (B) is strengthened. As a result, the alignment direction of the alignment layer is shifted by about 90° to the alignment direction of the aligning process.

Materials suitable for the polymer (A) are those which can be aligned in the same direction as that of the aligning process and the alignment regulation of which can be weakened by UV-irradiation, etc. Thus, it is preferable to use, but not limited to, as the polymer (A) backbone type polymers such as polyimide, polyamide, polyether, polyester and polyurethane. It is more preferable to use polyimide or polyamide, in particular, those containing fluorine or siloxane group.

On the other hand, examples of the polymer (B) include polyvinyl, polymethacrylate and polyacrylate having bulky groups in side chain such as polystyrene, polycyclohexyl methacrylate, polyvinyl anthracene, polyvinyl norbornene, polyvinyl butylstyrene, polycyclohexyl acrylate, polycyclohexyl methacrylate,

polyvinylnorbornylmethacrylate, polyvinylisoboronyl, polydicyclopentenyloxyethylmethacrylate. It is preferable to use polyacenaphthylene, polyvinyl diphenyl, polyvinyl naphthalene, polyvinyl formal, polyvinylpyridine-N-oxide, polyphenyl methacrylate, polyvinyl carbazole and polyvinyltoluene. Also, polyvinyl cinnamate can be used. These polymers (B) can establish uniform alignment after the irradiation with UV light, etc. Some of these materials show scarcely any alignment by the aligning process. In these cases, however, uniform alignment can be established by UV-irradiation. Although it still remains unknown why uniform alignment can be obtained by the irradiation with UV light, etc., it is assumed that the irradiation with energy beam such as UV light might cause rearrangement of the polymer molecular chains in the alignment direction established by the aligning process. Alternatively, polymerization or crosslinking might occur in some chemical structures. It is also possible that the terminal group in the side chain of a side chain type polymer is substituted by vinyl, acrylate, etc. and then crosslinked with the UV-irradiation to thereby fix the alignment.

It is still preferable that the polymer (B) further has a polarizable group in the side chain carrying the bulky group. The polarizability can improve the alignment. Examples of such polymer (B) include polyvinylbenzyl hexafluoroisopropyl ether, polyvinylpyridine, polyvinylpyridine-N-oxide, polyvinyl carbazole, polyvinyl methyl ketone, polyvinylpyridine-divinylbenzene, polyvinyl (1-methoxy)-p-carboxyphenylcarbaldehyde, polyvinyl chloroacetate, polyvinyl acetate, polyvinylbenzyl chloride, polyvinyl imidazole, polyvinyl phthalimide, polyvinyl benzoic acid, polyvinyl aminobenzene, polyvinyl phenol, polyvinyl chyclohexylamine, polyvinyl naphthylamine, polyvinyl benzylamine, polyvinyl dimethylcyclohexylamine, polyvinyl phenylquinolinamine, polyvinyl quinolinecarboxamide, polyvinyl-b-carboline, polyvinyl cinnoline, polyvinyl quinazoline, polyvinyl purine, polyvinyl isoquinoline, polyvinyl quinoline, polyvinyl quinoxaline, polyvinyl phthalazine, polyvinyl naphthyridine, polyvinyl isoindole, polyvinyl indole, polyvinyl pyridazine, polyvinyl oxolane, polyvinyl-2-furaldehyde, polyvinyl inden-1-one, polyvinyl fluoren-9-one, polyvinyl-2-pyridone, polyvinyl-2-quinolone, polyvinyl-9-carbonyl fluorene, polyvinyl thiophene, polyvinyl acridine, polyvinyl phenylpyridine, polyvinyl fluorophenylpyridine, polyvinyl

fluorobenzene, polyvinyl fluoromethylbenzene, polyvinyl-o-trifluoromethylaniline, polyvinyl pentafluorobenzene, polyvinyl-o-methoxybenzaldehyde, polyvinyl cyanobenzene, polyvinyl methylcarbamoylbenzene, polyvinyl carbamoylimidazole, polyvinyl chlorobenzene, polyvinyl nitrobenzene, polyvinyl nitronaphthalene, polyvinyl aminonaphthalene, polyvinyl sulfobenzene, polyvinyl aminopyridine, polyvinyl carboxypyridine, polyvinyl hydroxybenzene, polyvinyl hydroxypyridine, polyvinyl fluoromethylpyridine, polyvinyl formylbenzene, polyvinyl aminoethylbenzene, polyvinyl hydroxymethylbenzene, polyvinyl trifluoroethylbenzene, polyvinyl cyanoethylbenzene, polyvinyl formylethylbenzene, polyvinyl methoxyaminobenzene, polyvinyl-4-amino-tetrafluoropyridine, polyvinyl difluoromethylbenzene, polyvinyl difluorobenzene, polyvinyl methoxybenzene, polyvinyl aminocyclohexane, polyvinyl aminocyclopentane, polyvinyl cyclohexanecarboxylic acid, polyvinyl hydroxycyclohexane, polyvinyl fluoromethylcyclohexane, polyvinyl cyanocyclohexane, polyvinyl formylcyclohexane, polyvinyldioxolane, polymethoxystyrene, polyvinylphtalimide, polyfluorostyrene, polydifluorostyrene, polytrifluorostyrene, polytetrafluorostyrene, polypentafluorostyrene, poltrifluoromethylstyrene, polybis(trifluoromethyl)styrene, polyvinylbenzyl hexafluoro isopropyether.

Furthermore, the particular examples of the polymer (B) include polyacrylates and polymethacryaltes obtained by replacing the vinyl group in polyvinyl compounds with acryl or methacryl group.

It is preferable in the present invention that the polymer (B) contains, at least partly, monomer unit(s) having a bulky group and/or polarizable group. Either a homopolymer or a copolymer with other monomer unit(s) may be used.

It is also possible that the polymer (B) is not irradiated with UV light but employed as a usual alignment layer.

The molecular weight of the polymer (B) preferably ranges from 1,000 to 900,000, more preferably from 10,000 to 500,000. To achieve excellent liquid crystal alignment, it is preferable that the polymer (B) has Tg of 100°C or above, more

preferably 120°C or above.

The appropriate mixing ratio of the polymers (A) to (B) and the irradiation dose of UV light, etc. are determined depending on the difference in alignment regulation between these polymers. The mixing ratio of the polymers (A) to (B) preferably ranges from 1 : 50 to 50 : 1. When the amount of the polymer (A) is too large, the alignment regulation by the polymer (A) would become dominant continuously, even though the alignment layer is irradiated with UV light, etc. In this case, the alignment direction is not shifted by about 90°. When the amount of the polymer (B) is too large, the alignment regulation by the polymer (B) would become dominant continuously. In this case, even though the alignment layer is not irradiated with UV light, etc., the alignment direction may be shifted by about 90° to the alignment direction established by the aligning process. The polymers (A) and (B) may be each a mixture of two or more polymers. The irradiation dose of UV light, etc. preferably ranges from 0.01 mJ to 50 J, more preferably from 0.1 mJ to 10 J. When the dose of UV light, etc. is too large, the polymers would be oxidized and thus the alignment falls into disorder. The wavelength of UV light, etc. preferably ranges from 150 to 450 nm, more preferably from 200 to 400 nm.

When a cell is assembled by arranging upper and lower substrates, each having the alignment layer of the present invention, in such a manner as the alignment directions of the substrates being at 90° to each other, the usual TN alignment is established without irradiation with UV light, etc., while TN alignment having a viewing angle shifted by about 90° to the usual alignment direction is established after the irradiation. By partly irradiating with UV light, therefore, two regions including one having the same viewing angle as that of the usual TN and another having a viewing angle shifted by about 90° thereto are formed in a single pixel, which makes it possible to decrease the viewing angle dependency of a liquid crystal display device.

Moreover, the use of the alignment layer of the present invention makes it possible to widen the viewing angle in three directions. When one of the substrates (upper and lower) of a liquid crystal cell is irradiated with UV light, etc., for example, cnly

the alignment direction of the alignment layer of the irradiated substrate is shifted by about 90°. If the upper and lower substrates sufficiently differ from each other in the alignment regulation or pretilt angle, then the alignment of the liquid crystal is regulated exclusively by the substrate having stronger alignment regulation or larger pretilt angle. By partly irradiating the upper and lower substrates with UV light, etc., three regions differing in viewing direction from each other can be formed, and thus the viewing angle can be widened in three directions. For example, when three regions (i.e., one wherein only the upper substrate is irradiated with UV light, etc.; one wherein upper and lower substrates are both irradiated; and one wherein only the lower substrate is irradiated) are formed as shown in Fig. 2, each of these three regions has the viewing direction shifted by 90(to the adjacent one and thus the viewing angle can be widened. Fig. 2 shows a case where the unirradiated parts have stronger alignment regulation or larger pretilt angle. Similarly, the viewing angle can be widened in a case where irradiated parts have stronger alignment regulation or larger pretilt angle.

Furthermore, the viewing angle can be widened in four directions by using the alignment layer of the present invention. Namely, when the regions to be irradiated (i.e., the center parts shown in Fig. 2) in the upper and lower substrates are irradiated at different doses, then the upper and lower substrates have different alignment regulation or pretilt angles from each other. In this case, the alignment of the liquid crystal is regulated by the substrate having stronger alignment regulation or larger pretilt angle. Therefore, it is possible by varying the UV irradiation dose to form a region where the upper substrate has stronger alignment regulation or larger pretilt angle than the lower substrate and another region where, on the contrary, the lower substrate has stronger alignment regulation or larger pretilt angle than the upper substrate. Upon the application of voltage, these two regions show upstanding directions of liquid crystal contrary to each other, thus giving regions differing by 180 (in viewing angle. When four regions including the above-mentioned two, one where only the upper substrate is irradiated with UV light, etc. and another one where only the lower substrate is irradiated (as shown in Fig. 2) are formed in a single pixel, the viewing angle is widened in four directions, and thus the problem of the viewing angle dependency on direction can be solved.

The alignment layer of the present invention can be produced by forming a polymer film on a glass or plastic substrate provided with a transparent electrode by spin coating or printing in accordance with a method well known in the art, then subjecting the film to aligning process followed by the irradiation with UV light or electron beam. In the present invention, it is also possible to use non-polarized UV light, which facilitates the production. It is preferable that the aligning process is carried out by the rubbing method, though the present invention is not limited thereto. By using a mask in the step of the irradiation with UV light or electron beam, regions with different viewing directions can be formed in a single pixel. These regions can be arbitrarily varied in size and shape by appropriately selecting the mask pattern. The mask size is determined depending on the display size. Namely, the mask may have the same size as the display, or a smaller mask may be used by using steppers. The pattern size of the mask is preferably controlled to several ten to 500 mm depending on the size of a pixel.

The difference in the alignment regulation between the upper and lower substrates may be controlled by regulating the mixing ratio of the polymers (A) and (B) or the irradiation dose of UV light, etc. Unless the upper and lower substrates are sufficiently different from each other in the alignment regulation, the liquid crystal is regulated by both of these substrates and thus undergoes parallel or anti-parallel alignment. In such a case, the parallel or anti-parallel alignment can be prevented to a certain extent by controlling the content of the chiral agent in the liquid crystal to alter the chiral pitch of the liquid crystal.

It is preferable that the alignment layer of the present invention has a pretilt angle of at least 0.1°, more preferably at least 1°. It is also preferable that the pretilt angle is varied by irradiating UV light, etc. This is because when one of the upper and lower substrates is irradiated with UV light, etc., different pretilt angles of the upper and lower substrates make it possible to suppress the occurrence of discrimination caused by the reverse upstanding of the liquid crystal upon the application of voltage. It is preferable that the difference between the pretilt angles is 0.1° or more, still preferably 1° or more.

This application claims priority to Japanese application Nos. 168,931/96, filed June 28, 1996 and 242,164/96, filed September 12, 1996, incorporated herein by reference.

Several publications also are referenced in the application. These references describe the state of the art to which this invention pertains, and are incorporated herein by reference.

EXAMPLES

To further illustrate the present invention in greater detail, and not by way of limitation, the following Examples will be given. Numerous changes and modifications can be made with respect to the invention.

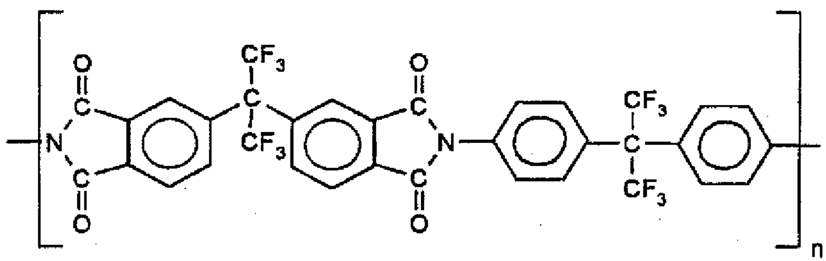
Example 1

A polyaramide-polysiloxane copolymer and polyvinyl carbazole were mixed at a ratio of 1 : 1 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was irradiated with UV light for 5 minutes by using a lattice-patterned mask (100 mm x 100 mm) under a high pressure mercury lamp (105 W) to thereby form two regions (100 mm x 100 mm) adjacent to each other, namely, the UV-irradiated region and unirradiated region. Then these upper and lower substrates were arranged so that the UV-irradiated parts were laid one on top of another while the unirradiated parts were similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5043LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing direction of the

UV-irradiated part was shifted by about 90° to that of the unirradiated part, whereby the viewing angle of the cell was widened.

Example 2

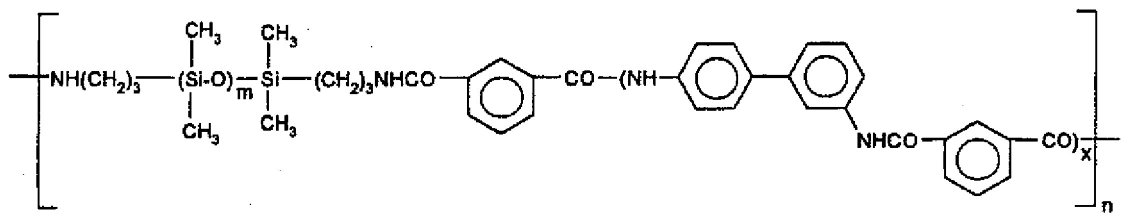
A polyimide represented by the following general formula:



and polyvinyl carbazole were mixed at a ratio of 1 : 3 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was irradiated with UV light for 5 minutes (the upper substrate) or 3 minutes (the lower substrate) by using a lattice-patterned mask (100 mm x 100 mm) under a high pressure mercury lamp (105 W) to thereby form on each substrate two regions (100 mm x 100 mm) adjacent to each other, namely, the UV-irradiated region and unirradiated region. Then these upper and lower substrates were arranged so that the UV-irradiated parts were laid one on top of another while the unirradiated parts were similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5043LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing direction of the UV-irradiated part was shifted by about 90° to that of the unirradiated part, whereby the viewing angle of the cell was widened.

Example 3

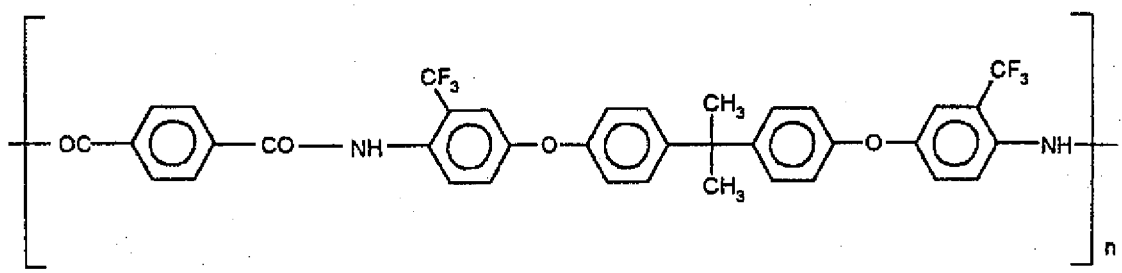
A polyaramide/polysiloxane block copolymer represented by the following general formula:



and polyvinyl-4-pyridine were mixed at a ratio of 1 : 4 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was partly irradiated with UV light by using a perforated mask (100 mm x 300 mm) under a high pressure mercury lamp (105 W). The upper substrate was thus irradiated with UV light so that three regions of 100 x 300 mm (i.e., the unirradiated part and those irradiated respectively for 1 minute and 10 seconds) were located adjacently to each other. On the other hand, the lower substrate was similarly irradiated with UV light so that three regions (i.e., the parts irradiated respectively for 10 seconds and 5 minutes and the unirradiated part) were located adjacently to each other. Then these upper and lower substrates were arranged so that the unirradiated parts and the parts irradiated for 10 seconds were laid one on top of another while the parts irradiated for 1 minute and 5 minutes were laid similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material having a chiral pitch adjusted to 22 mm clockwise (LIXON 5043XX, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing directions of the three parts UV-irradiated at various doses in the upper and lower substrates were each shifted by about 90° to that of the adjacent part, whereby the viewing angle of the cell was widened in three directions.

Example 4

A polymer represented by the following general formula:



and a poly(styrene-vinyl(1-methoxy)-p-phenylcarbaldehyde) copolymer were mixed at a ratio of 1 : 7 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was partly irradiated with UV light by using a perforated mask (100 mm x 300 mm) under a high pressure mercury lamp (105 W). The upper substrate was thus irradiated with UV light so that three regions of 100 x 300 mm (i.e., the unirradiated part, the unirradiated part and that irradiated for 5 minutes) were located adjacently to each other in this order. On the other hand, the lower substrate was similarly irradiated with UV light so that three regions (i.e., the part irradiated for 5 minutes and the unirradiated parts) were located adjacently to each other in this order. Then these upper and lower substrates were arranged so that the unirradiated parts were laid one on top of another while the parts irradiated for 5 minutes were laid similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material having a chiral pitch adjusted to 22 mm opposite clockwise (LIXON 5043XX, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing directions of the three regions UV-irradiated at various doses in the upper and lower substrates were each shifted by about 90° to that of the adjacent part, whereby the viewing angle of the cell was widened in three

directions.

Example 5

The polyaramide/polysiloxane block copolymer employed in Example 3 and polyvinyl urethane were mixed at a ratio of 1 : 5 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. Then a liquid crystal cell was formed in the same manner as the one described in Example 3. A nematic liquid crystal material (LIXON 5043LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing directions of the three regions UV-irradiated at various doses in the upper and lower substrates were each shifted by about 90° to that of the adjacent part, whereby the viewing angle of the cell was widened in three directions.

Example 6

The polyaramide/polysiloxane copolymer employed in Example 1 and polyvinylpyridine-N-oxide were mixed at a ratio of 1 : 10 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was partly irradiated with UV light by using a perforated mask (100 mm x 100 mm) under a high pressure mercury lamp (105 W). The upper substrate was thus irradiated with UV light so that four regions of 100 x 100 mm (i.e., the unirradiated part and those irradiated respectively for 3, 3 and 5 minutes) were located adjacently to each other in this order. On the other hand, the lower substrate was similarly irradiated with UV light so that four regions (i.e., the parts irradiated respectively for 3 and 5 minutes, the unirradiated part and the part irradiated for 3 minutes) were located adjacently to each other in this order. Then these upper and lower substrates were arranged so that the unirradiated parts and

the parts irradiated for 3 minutes were laid one on top of another while the parts irradiated for 5 minutes and 3 minutes were laid similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material having a chiral pitch adjusted to 22 mm clockwise (LIXON 5043XX, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing directions of the four regions UV-irradiated at various doses in the upper and lower substrates were each shifted by about 90° to that of the adjacent part, whereby the viewing angle of the cell was widened in four directions.

Example 7

The polyamide employed in Example 4 and polyvinyl-4-pyridine were mixed at a ratio of 1 : 5 and dissolved in N-methylpyrrolidone to give a concentration of 2.5 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was partly irradiated with UV light by using a perforated mask (100 mm x 50 mm) under a high pressure mercury lamp (105 W). The upper substrate was thus irradiated with UV light so that four regions of 100 x 50 mm (i.e., the unirradiated part and those irradiated respectively for 1 minute, 10 seconds and 3 minutes) were located adjacently to each other in this order. On the other hand, the lower substrate was similarly irradiated with UV light so that four regions (i.e., the parts irradiated respectively for 10 seconds and 3 minutes, the unirradiated part and the part irradiated for 1 minute) were located adjacently to each other in this order. Then these upper and lower substrates were arranged so that the unirradiated parts and the parts irradiated for 10 seconds, 1 minute and 3 minutes were each laid one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material having a chiral pitch adjusted to 22 mm clockwise (LIXON 5043XX, manufactured by Chisso Petrochemical Co.) was

filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing directions of the four regions UV-irradiated at various doses in the upper and lower substrates were each shifted by about 90° to that of the adjacent part, whereby the viewing angle of the cell was widened in four directions.

Example 8

Polyvinyl cinnamate was dissolved in N-methylpyrrolidone to give a concentration of 3.0 % by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour to thereby form a polymer film. Then a liquid crystal cell was formed in the same manner as the one described in Example 2. A nematic liquid crystal material (LIXON 5043LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment. Evaluation of the viewing angle characteristics of this liquid crystal cell indicated that the viewing direction or the UV-irradiated part was shifted by about 90° to that of the unirradiated part, whereby the viewing angle of the cell was widened.

Example 9

Polyaramide silicone and poly-4-allyloxyloyloxystyrene were mixed at a ratio of 1 : 10 and dissolved in N-methylpyrrolidone to give a concentration of 3 % by weight. The solution thus obtained was applied onto glass substrates each provided with an ITO electrode by the spin coating method at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 (C for 1 hour and rubbed. Next, it was irradiated with UV light under a high pressure mercury lamp (105 W) for 3 minutes. These upper and lower substrates were arranged in such a manner as the rubbing directions being at 90(to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5047LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110 °C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle

shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 10

Polyaramide silicone and polyvinyl carbazole were mixed at a ratio of 1 : 10 and dissolved in N-methylpyrrolidone to give a concentration of 3 % by weight. The solution thus obtained was applied onto glass substrates each provided with an ITO electrode by the spin coating method at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour and rubbed. Next, it was irradiated with UV light under a high pressure mercury lamp (105 W) for 3 minutes. These upper and lower substrates were arranged in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5047LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110 °C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 11

Polystyrene and polyaramide silicone were mixed at a ratio of 1 : 20 and dissolved in N-methylpyrrolidone to give a concentration of 3 % by weight. The solution thus obtained was applied onto glass substrates each provided with an ITO electrode by the spin coating method at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour and rubbed. Next, it was irradiated with UV light by using a mask under a high pressure mercury lamp (105 W) for 3 minutes to thereby form an UV-irradiated part and an unirradiated part. These upper and lower substrates were arranged so that the unirradiated parts were laid one on top of another while the irradiated parts were similarly laid similarly one on top of another in such a manner as the rubbing directions being at 9° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5047LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110 °C. Observation of this cell indicated that there were two regions including one

having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 12

The polyaramide/polysiloxane block copolymer employed in Example 1 and polyvinyl naphthalene were mixed at a ratio of 1 : 5 and dissolved in N-methylpyrrolidone to give a concentration of 3 % by weight. The solution thus obtained was applied onto glass substrates each provided with an ITO electrode by the spin coating method at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour and rubbed. Next, it was irradiated with UV light by using a mask under a high pressure mercury lamp (105 W) for 3 minutes to thereby form an UV-irradiated part and an unirradiated part. These upper and lower substrates were arranged so that the unirradiated parts were laid one on top of another while the irradiated parts were similarly laid similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5047LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110 °C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 13

The polyaramide/polysiloxane block copolymer employed in Example 1 and polycyclohexyl methacrylate were mixed at a ratio of 1 : 10 and dissolved in N-methylpyrrolidone to give a concentration of 3 % by weight. The solution thus obtained was applied onto glass substrates each provided with an ITO electrode by the spin coating method at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour and rubbed. Next, it was irradiated with UV light by using a mask under a high pressure mercury lamp (105 W) for 3 minutes to thereby form an UV-irradiated

part and an unirradiated part. These upper and lower substrates were arranged so that the unirradiated parts were laid one on top of another while the irradiated parts were similarly laid similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5047LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110 °C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 14

The polyaramide/polysiloxane block copolymer employed in Example 1 and polyvinyl formal were mixed at a ratio of 1 : 10 and dissolved in N-methylpyrrolidone to give a concentration of 3 % by weight. The solution thus obtained was applied onto glass substrates each provided with an ITO electrode by the spin coating method at 2,000 r.p.m. for 20 seconds. Then it was dried at 180 °C for 1 hour and rubbed. Next, it was irradiated with UV light by using a mask under a high pressure mercury lamp (105 W) for 3 minutes to thereby form an UV-irradiated part and an unirradiated part. These upper and lower substrates were arranged so that the unirradiated parts were laid one on top of another while the irradiated parts were similarly laid similarly one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 mm. A nematic liquid crystal material (LIXON 5047LC, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110 °C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 15

The polyamide employed in Example 4 and polymethoxystyrene were mixed at a

ratio of 1:10 and dissolved in N-methylpyrrolidone to give a concentration of 2.5% by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180°C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was irradiated with UV light by using a mask (100 µm - 50 µm) under a high pressure mercury lamp (105W) for 3 minutes to thereby form an UV-irradiated parts were similarly laid one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 µm. A nematic liquid crystal material having a chiral pitch adjusted to 22 µm clockwise (LIXON 5043xx, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110°C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 16

The polyamide employed in Example 4 and polyvinylpyridine-co-fluorostyrene were mixed at a ratio of 1:15 and dissolved in N-methylpyrrolidone to give a concentration of 2.5% by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180°C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was irradiated with UV light by using a mask (100 µm - 50 µm) under a high pressure mercury lamp (105W) for 3 minutes to thereby form an UV-irradiated parts were similarly laid one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 µm. A nematic liquid crystal material having a chiral pitch adjusted to 22 µm clockwise (LIXON 5043xx, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110°C. Observation of this cell indicated that there were two regions including one

having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 17

The polyamide employed in Example 4 and polyfluorostyrene, were mixed at a ratio of 1:10 and dissolved in N-methylpyrrolidone to give a concentration of 2.5% by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180°C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was irradiated with UV light by using a mask (100 µm - 50 µm) under a high pressure mercury lamp (105W) for 3 minutes to thereby form an UV-irradiated parts were similarly laid one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 µm. A nematic liquid crystal material having a chiral pitch adjusted to 22 µm clockwise (LIXON 5043xx, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110°C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that of a common TN cell and another having a viewing angle shifted by 90° thereto, whereby the viewing angle of the cell was widened.

Example 18

The polyamide employed in Example 4 and polybis(trifluoromethyl)styrene were mixed at a ratio of 1:5 and dissolved in N-methylpyrrolidone to give a concentration of 2.5% by weight. The solution thus obtained was applied onto glass substrates each provided with a transparent electrode by using a spinner at 2,000 r.p.m. for 20 seconds. Then it was dried at 180°C for 1 hour to thereby form a polymer film having a thickness of about 50 nm. Then the film was aligned by rubbing with a nylon fabric in one direction. Next, the alignment layer was irradiated with UV light by using a

mask (100 µm - 50 µm) under a high pressure mercury lamp (105W) for 3 minutes to thereby form an UV-irradiated parts were similarly laid one on top of another in such a manner as the rubbing directions being at 90° to each other, thus forming a liquid crystal cell with a cell gap of 5 µm. A nematic liquid crystal material having a chiral pitch adjusted to 22 µm clockwise (LIXON 5043xx, manufactured by Chisso Petrochemical Co.) was filled into the cell and subjected to a heat treatment at 110°C. Observation of this cell indicated that there were two regions including one having the same viewing direction as that.

Comparative Example 1

Liquid crystal cells were formed by using the alignment layers employed in Examples 1 to 7 which were not UV-irradiated. Evaluation of the viewing angle characteristics of these liquid crystal cells indicated that no region having a different viewing angle was formed and thus the viewing angle was not widened.

Patentclaims:

1. An alignment layer for a nematic liquid crystal display device which comprises at least a portion of said alignment layer which after completion of the aligning process is irradiated with UV light or an electron beam sufficient to cause the alignment direction of the alignment layer within the irradiated region to shift about 90° relative to the alignment direction established by the aligning process.

2. An alignment layer as claimed in Claim 1 which comprises at least one polymer material containing a polymer material having such properties as to align the liquid crystal in a direction shifted to about 90° relative to the direction established by the aligning process when irradiated with UV light or an electron beam after the completion of the aligning process.

3. An alignment layer as claimed in Claim 1 or 2 containing at least one polymer compound [polymer (A)], which has such properties as to align the liquid crystal in the direction of the aligning process when the alignment layer is irradiated with UV light or an electron beam after the completion of the aligning process, and at least one polymer compound [polymer (B)] which has such properties as to align the liquid crystal upon irradiation in the direction shifted by about 90° relative to the direction of the aligning process.

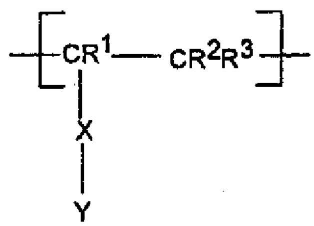
4. An alignment layer as claimed in Claim 3, wherein said polymer (B) is a polymer compound having a cyclic structure carrying at least 4 carbon atoms.

5. An alignment layer as claimed in Claim 4, wherein said polymer (B) is a polymer compound further having a polarizable group.

6. An alignment layer as claimed in Claim 5, wherein said polarizable group is at least one group selected from the following groups:
-C(=O)-, -CN, -C(=S)-, -SO-, $-SO_2-$, -NH-, $-NR^4-$, $-NR^5R^6$, $-NH_2$, =N-, $-NO_2$, -N=O, -OH, -Cl, -F, -CHO, -COO-, -O- and -S-
wherein R^4, R^5 and R^6, identical or different, each represent an alkyl group having 1

to 10 carbon atoms.

7. An alignment layer as claimed in any of claims 4 to 6, wherein said polymer (B) contains a repeating unit represented by the following general formula (I):



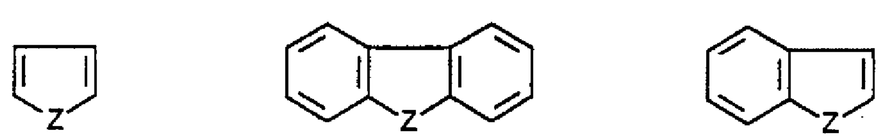
(I)

wherein R^1, R^2 and R^3, identical or different, each represent a hydrogen atom, a halogen atom or an optionally halogenated alkyl group having 1 to 10 carbon atoms; and

X represents a spacer unit which is a chain hydrocarbon group having 1 to 10 carbon atoms, a cyclic hydrocarbon group having 4 to 15 carbon atoms, -COO-, $-OCH_2-$, -OCO- or a direct bond; and

Y represents a cyclic hydrocarbon group having 4 to 15 carbon atoms and optionally containing at least one group selected from the following groups: -C(=O)-, -C(N), -C(=S)-, -SO-, $-SO_2-$, -NH-, $-NR^4-$, $-NR^5R^6$, $-NH_2$, =N-, $-NO_2$, -N=O, -OH, -Cl, -F, -CHO, -COO-, -O- and -S-;
wherein R^4, R^5 and R^6, identical or different, each represent an alkyl group having 1 to 10 carbon atoms; and,
optionally being substituted by an alkyl group having 1 to 10 carbon atoms or a phenyl group.

8. An alignment layer as claimed in Claim 7, wherein Y is an optionally substituted cyclic hydrocarbon group selected from the following groups:



wherein Z represents a nitrogen, substituted with H, an alkyl group having from 1 to 10 carbon atoms or a phenyl group, sulfur or oxygen atom; and

one to three =CH- groups on the ring may be replaced with =N-.

9. An alignment layer as claimed in any of Claims 3 to 8, wherein said polymer (A) is a polyimide, polyamide, polyether, polyester or polyurethane.

10. An alignment layer as claimed in any of Claims 3 to 9, wherein said polymer (A) has a fluorine atom or a siloxane group.

11. An alignment layer as claimed in Claim 9, wherein said polymer (A) is a polyaramide siloxane compound.

12. A process for producing an alignment layer for a nematic liquid crystal display device characterized in that a part or the whole of the alignment layer is irradiated with UV light or electron beam after the completion of the aligning process such that the alignment direction of the alignment layer is shifted by about 90° relative to the alignment direction established by the aligning process.

13. A liquid crystal display device comprising a nematic liquid crystal material filled between a pair of substrates each comprising a transparent electrode and an alignment layer formed thereon in a manner such that the alignment layers are arranged inside and an alignment layer as claimed in any of claims 1 to 11 is formed on at least one of said substrates.

Fig. 1

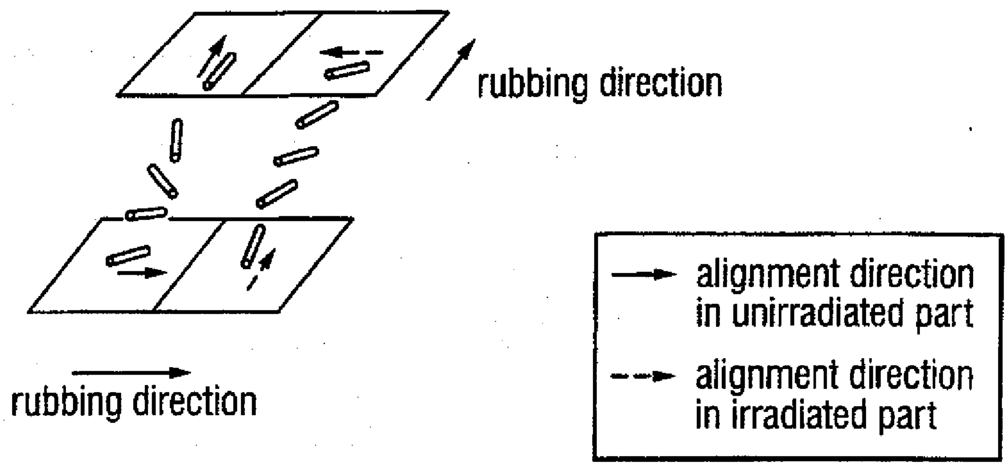
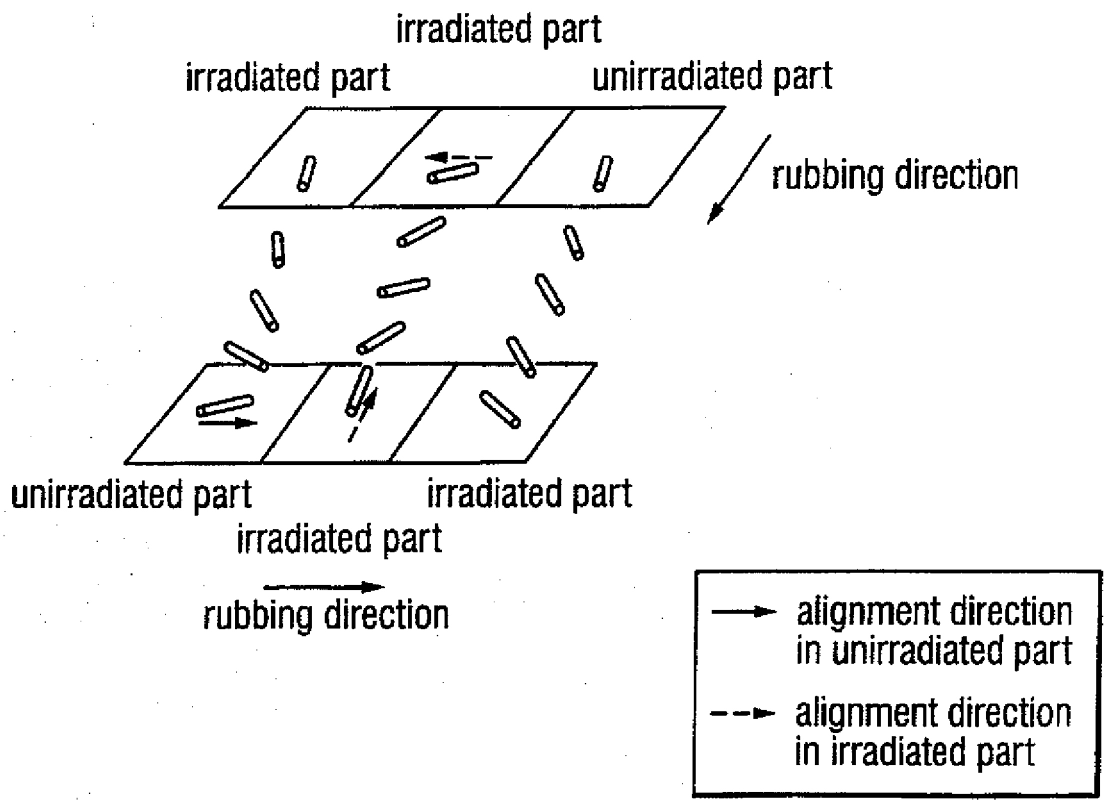

rubbing direction
rubbing direction
alignment direction in unirradiated part
alignment direction in irradiated part

Fig. 2


irradiated part
irradiated part
unirradiated part
rubbing direction
unirradiated part
irradiated part
irradiated part
rubbing direction
alignment direction in unirradiated part
alignment direction in irradiated part

INTERNATIONAL SEARCH REPORT

Inter   nal Application No
PCT/EP 97/03302

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02F1/1337

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GIBBONS W M ET AL: "Surface-mediated alignment of nematic liquid crystals with polarized laser light" NATURE, 2 MAY 1991, UK, vol. 351, no. 6321, ISSN 0028-0836, pages 49-50, XP000351721 see page 49 - page 50; figure 2 ---	1,2,12, 13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

2

Date of the actual completion of the international search	Date of mailing of the international search report
9 October 1997	27/10/1997

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Diot, P

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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2

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Information on patent family members

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